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Eradication of *Mycoplasma hyopneumoniae* from Infected Swine Herds Joining the LSO 2000 Health Class

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Heinonen M, Autio T, Saloniemi H, Tuovinen V: Eradication of *Mycoplasma Hyopneumoniae* from infected swine herds joining the LSO 2000 health class. Acta vet. scand. 1999, 40, 241-252. – The study was conducted in order to determine if eradication of swine enzootic pneumoniae (SEP) had succeeded with different variants of partial depopulation during the eradication programme on swine farrowing farms joining a health class, LSO 2000. The farms in the health class need to be free from swine enzootic pneumoniae, swine dysentery, sarcoptic mange and atrophic rhinitis. Twenty-one eradication attempts for *M. hyopneumoniae* were carried out using different variants based on separating adult animals for 2 weeks from infected young pigs which were not returned to the herd. The infected young pigs were kept in the same building (variant 1) in 4 herds and on the same compound (variant 2) as disease-free pigs in 12 herds. The infected young pigs were finally all sold. In 5 herds only adult animals were present during the eradication (variant 3). The eradication attempt succeeded in 81% and failed or remained uncertain in 19% of the herds. The result was confirmed with 1) frequent clinical follow-up of the health status in the herds (both the farrowing and the finishing units) joining the LSO 2000 health class 2) milk and/or blood serology. Possible causes of the failure of the eradication attempt were described: a short distance between infected and uninfected animals, the time period between diagnosis of SEP and initiation of the programme, the age of the youngest animal kept on the farm, the period of time when animals with different status were reared close to each other, the medications used, the cleaning of the facilities during the programme and the season. Further, a good cooperation between the farmer, the local veterinarian and the animal health service of the slaughterhouse was an essential part of the initiation and the follow-up of the programme. The secondary aim of the study was to collect information about the expenses during the programme. Only 57% of the farmers gave some estimates for the expenses on their farms. For variants 1, 2 and 3 the expenses were 879, 1110 and 1274 FIM per sow (1 USD = 5.5 FIM), respectively ($p>0.1$).

Enzootic pneumoniae; medication; ELISA.

Introduction

Swine enzootic pneumonia (SEP) caused by *Mycoplasma hyopneumoniae* is one of the most common diseases causing major economic losses for the swine industry. The first methods of fighting against the disease were reported already 60 years ago (*Waldmann & Radtke* 1937). Since then new methods for eradicating the disease have been developed, and they are all based on the fact that *M. hyopneumoniae* is spread by young animals, and old animals ac-

quire immunity against the agent. The eradication programme using partial depopulation known as the Swiss method consists of a time period of about 2 weeks during which there are no animals younger than 10 months on the farm (*Zimmermann* 1990, *Zimmermann et al.* 1989). During this time the animals are medicated and the piglets born after this period will not get infected, because there are no young animals on the farm carrying the disease. The method has been tested also in Denmark (*Baekbo et al.* 1994, *Madsen & Larsen* 1996), Norway (*Lium et al.* 1994) and Sweden (*Wallgren et al.* 1993). In the study by *Wallgren et al.* (1993) some of the herds also housed *M. hyopneumoniae* contagious pigs during the eradication programme, and in the study of *Lium et al.* (1994) suckling piglets were present when the eradication project was carried out. The cutback in production is the major element which causes financial losses during an eradication attempt. When the Swiss method is applied, the farmer needs extra facilities far away from his own premises or he needs to have a long interruption in farrowings in order to achieve a piglet-free period of 2 weeks on the farm. Both necessities are expensive. In the swine industry new quality chains require freedom from some diseases (*Tuovinen et al.* 1997), which makes the farmers more interested in eradicating those diseases. In order to make it possible for more farmers to start eradication programmes for *M. hyopneumoniae* on their farms, less expensive methods need to be developed.

This study was conducted in order to determine if eradication of *M. hyopneumoniae* had been successful in infected swine herds joining a health class system, LSO 2000 quality chain (*Tuovinen et al.* 1997). The present study aimed to establish how the different variants of the partial depopulation programmes had succeeded, also when infected young pigs were kept in close proximity to healthy piglets during the programme. Other objectives were to describe possible risk factors for failure and the expenses during the eradication programmes.

Materials and methods

Herds and eradication strategies

M. hyopneumoniae eradication was attempted on 21 farms during the years 1994-1996. The median size of the farms was 50 sows/herd, ranging from 20 to 348. Most of the herds (62%) were farrowing units, and the rest had an integrated production with a median size of 255 finishing pigs per herd, ranging from 150 to 2130. Before the eradication attempt, colostrum samples of at least 10 sows (20, 10-33) were tested with an enzyme linked immunosorbent assay (ELISA; DAKO® *Mycoplasma hyopneumoniae* ELISA kit, DAKO A/S, Glostrup, Denmark). The ELISA result for a herd was considered positive if ≥10% of the samples tested positive (*Rautiainen et al.* 1996). The herds had a median number of 7 positive samples (2-20) and a median percentage of 30% positive samples (13%-90%), see Table 1. The results from lung condemnations in the slaughterhouse were available if more than 50 finishing pigs per year had been slaughtered in a herd. The lungs were condemned if there was a pneumonic lesion larger than a Finnish 5 mark coin (diameter 2.4 cm) in the lung. The herds in the study had a median of 7.0% (2.1%-13.9%) of lungs condemned before the eradication (Table 1).

The eradication programmes were based on separating adult animals from young infected pigs for at least 2 weeks during which time the adult animals were treated with antibiotics and the buildings were cleaned. The antibiotics used were either lincomycin (Lincomix premix®, Cheminex Laboratories Ltd., Northants, UK) with a dosis of 44 grams/ton feed, or tiamulin (Tiamutin®, Sandoz AG, Basel, Swit-

Table 1. The follow-up of the herds before and after the *M. hyopneumoniae* eradication attempt with different variants: Variant 1 = infected young pigs were kept isolated in the same building as disease-free pigs, Variant 2 = infected young pigs were kept on the same compound but not in the same building as disease-free pigs, Variant 3 = only adult animals were kept on the same compound as disease-free pigs.

Variant and herd	No. of sows	Antibodies in colostrum		Antibodies in serum after (pos)	Lung condemnations	
		Before, (pos)	After, (pos)		Before, % (number)	After, % (number)
Variant 1:						
S1	348	15 (12)	48 (0)	26 (0)	5.8% (3853)	1.6% (4556)
S8	35	15 (4)	11 (0)	7 (0)	Not done	Not done
S10	60	13 (3)	14 (0)	20 (0)	6.6% (1854)	0.4% (1820)
S15	50	30 (6)	10 (0)	10 (0)	6.6% (181)	0.8% (124)
Variant 2:						
S3	65	32 (10)	11 (0)	10 (0)	Not done	Not done
S4	60	31 (7)	15 (0)	0	7.5% (187)	1.1% (93)
S5	70	18 (3)	0	18 (0)	7.4% (2006)	5.7% (2674)
S6	50	10 (9)	0	26 (0)	6.4% (78)	Not done
S7	40	26 (8)	21 (0)	8 (0)	7.0% (130)	Not done
S9	40	15 (2)	75 (0)	0	12.6% (198)	3.7% (540)
S11	30	30 (16)	11 (0)	12 (0)	Not done	Not done
S12	20	10 (3)	35 (4*)	30 (0)	4.5% (176)	1.1% (348)
S13	20	20 (3)	19 (0)	24 (0)	Not done	Not done
S16	45	20 (15)	16 (0)	10 (0)	4.9% (428)	0.2% (526)
Variant 3:						
S2	50	30 (16)	4 (0)	16 (0)	2.1% (94)	2.0% (50)
S14	40	18 (8)	9 (1)	14 (0)	11.2% (1278)	1.6% (1039)
S17	35	30 (20)	12 (0)	8 (0)	Not done	4.8% (63)
Median	45	20 (8)	12 (0)	11 (0)	6.6%[a] (198)	1.6%[b] (526)
Variant 2						
F1	32	27 (5)	38 (1)	52 (11)	9.9% (181)	5.6% (252)
U2	80	33 (7)	13 (3)	0	13.9% (202)	9.4% (572)
Variant 3						
F2	150	30 (7)	0	24 (7)	7.6% (263)	3.5 % (577)
U1	55	15 (7)	0	27 (9)	Not done	Not done
Median	67.5	28.5 (6)	6.5 (2)	25.5 (8)	9.9%[a] (202)	5.6%[a] (572)

Colostrum = number of colostrum samples tested with ELISA (number positive).
Serum = number of serum samples tested with ELISA (number positive).
Lung condemnations = percentage of lung condemnations (number checked).
S-herds = herds succeeded in the eradication, F-herds = herds failed in the eradication, U-herds = herds uncertain, because of reinfection.
* accidentally 4 old sows were sampled after the eradication program.
Values with different superscripts within the same rows differ significantly ($p = 0.001$).

zerland) with a dosis of 200 grams/ ton feed for 14 days orally. On some farms also an injection of lincomycin with 10 mg/kg (Lincocin®, Pharmacia & Upjohn, Puurs, Belgium) was used on the first and the last day of the oral treatment. The cleaning included washing with water, disinfection and thorough drying of the facilities. The farmers were recommended to keep only pigs older than 10 months. On some farms some young animals were kept temporarily in the herd separated from the older animals (see below, variants 1 and 2), but they were all sold before the end of the eradication programme. The medicated sows, gilts and boars and the new piglets born from the sows after medication were considered to be disease-free, all other animals were regarded as infected. The herds had a planned interruption in farrowings or some of the sows farrowed or nursed their piglets before medication during the eradication programme in rooms not housing new disease-free piglets. After weaning these sows were separated from young animals and treated with antibiotics as described. After the medication the sows were returned into the herd. The infected piglets born before the sows were medicated did not return to the herds, but were all sold.

Three variants of the programme were used:

1) Infected young pigs were kept in the same building as disease-free pigs (4 herds). The rooms were totally separated (ventilation, equipment, clothing etc.) as long as infected young pigs were housed on the farm.
2) Infected young pigs were kept on the same compound in isolation, but not in the same building as disease-free pigs (12 herds).
3) Only adult, medicated animals were kept on the same compound as disease-free piglets (5 herds). This variant is the equivalent of the Swiss method.

On each farm the eradication programme was planned individually and the variant of the programme was selected according to the availability of extra facilities, according to the possibilities for using different compartments for different animal groups and according to the availability of workers during the eradication programme on the farm. If the farmer had extra facilities he could use them during the eradication programme for the infected young pigs or for sows farrowing right before or during the eradication programme. If no extra facilities were available an interruption in farrowings was needed. The following were considered to be risk factors which could lead to the failure of the eradication: the distances between infected young pigs and disease-free piglets, the length of the time period between the diagnosis of SEP with positive colostrum samples and the beginning of the eradication programme, the age of the youngest pig remaining in the herd, the length of time when infected and disease-free animals were housed on the same compound, the medications used, cleaning of the facilities and the season. After the eradication programme on each farm the factors were assessed using questionnaire and telephone surveys of the farmers. The farmers were also asked to estimate the expense of the programme to the farm.

Monitoring the effect of the eradication attempts

The results were monitored by using the following methods:

1) The herds were clinically controlled for signs of SEP by the end of March 1998. The herds joined the LSO 2000 health class (*Tuovinen et al.* 1997), which includes clinical control of disease signs (SEP, atrophic rhinitis, swine dysentery and sarcoptic mange) 4 times per year by a local practising veterinarian. If there were no signs of the above mentioned diseases the veterinarians signed a certificate which was con-

trolled by the quality officer in the animal health service. If the quality officer did not get the certificate every 3 months, the herd was rejected from the health class.

2) The herds were tested serologically by collecting blood and colostrum samples for determination of *M. hyopneumoniae* antibodies by the end of 1997. If antibodies were found, further samples were asked for immediately and the history of the sows giving positive samples was checked.
3) Slaughterhouse reports concerning lung condemnations from the herds in the study were collected by the end of 1997.
4) The finishing herds buying the feeder pigs from the farrowing units were observed for signs of enzootic pneumonia by local veterinarians who checked the farms at least 2 times per finishing period. In the LSO 2000 quality chain the piglets from the farrowing units are sorted in pens in finishing units by herds of origin, and if SEP is found (= antibodies to *M. hyopneumoniae* were found in the finishing unit after clinical signs of SEP), the infection is immediately traced to the possible farrowing units. The feedback from the finishing units by the end of 1997 was verified by collecting the number of feeder pigs sold from the herds in the present study to finishing units raising only health class feeder pigs. Also, the possible connections of farrowing units in the present study with the outbreaks of SEP in the finishing units raising health class pigs were checked.

The eradication programmes were classified as successful (S-herds) if the herds had no clinical signs of SEP, their serum and colostrum samples were negative for *M. hyopneumoniae* and they had been able to remain in the LSO 2000 health class (*Tuovinen et al.* 1997). The program was regarded as a failure (F-herds) if positive colostrum samples were obtained from animals born after the eradication programme and the pigs had clinical signs of SEP on the farm. The result was considered as uncertain (U-herds) if replacement gilts from proven infected herds had brought the disease again into the herd after the programme and this had led to clinical signs of SEP in the herds verified with antibodies to *M. hyopneumoniae* in serum or colostrum samples.

Statistical methods

The Wilcoxon signed rank test was used to test the lung condemnation percentage before and after the eradication attempts. Comparisons between the expenses of the different variants of the programme were tested with Kruskall-Wallis one-way analysis of variance.

Results

Results and monitoring of the eradication attempts

The eradication programme succeeded in 17 herds (81%, S-herds), failed in 2 herds (9.5%, F-herds) and remained uncertain in 2 herds (9.5%, U-herds).

In March 1998, the S-herds had been followed clinically for 26 (17-35) months after the beginning of the eradication programme on each farm. Out of the 17 S-herds 16 had been in the LSO 2000 health class at least 12 months the median being 19 months (12-32 months). Local veterinarians had checked the herds clinically for absence of clinical signs of SEP every third month at least 4 times. One herd (herd S5) had joined the quality chain 28 months after the beginning of the program on the farm. On this farm the local veterinarian had checked for the absence of clinical signs only twice according to the regulations in the quality chain, but the owner claimed that there had been no clinical signs of SEP after the eradication programme.

The number of sow colostrum samples and

serum samples of pigs aged 8-12 weeks analysed for the presence of antibodies to *M. hyopneumoniae* are presented in Table 1. In one herd (S12) 4 samples were positive for *M. hyopneumoniae.* The farmer had accidentally milked 4 old sows which had been present in the herd already before the programme. In one herd (S14) antibodies were detected in one out of 9 samples and the farmer was asked to send blood samples to the laboratory immediately. Antibodies were not detected in any other samples on that farm. All other ELISA samples in all herds were negative for *M. hyopneumoniae* after the programme. The percentage of lung condemnations had decreased on S-herds from 6.6% to 1.6% ($p = 0.001$) and on F+U – herds from 9.9% to 5.6% ($p = 0.12$).

Fourteen out of 17 S-herds had sold altogether 7531 feeder pigs to finishing units rearing only health class piglets, and no outbreaks of SEP has been traced to the farrowing herds concerning this study. Three S-herds (S5, S10 and S14) had grown all of their piglets themselves and their ELISA samples and lung condemnation figures can be seen in Table 1.

Performance of the eradication attempts

The success of the eradication attempts according to the different variants of the programme were as follows: All herds using variant 1 succeeded. The herds using variants 2 and 3 succeeded in 10 (83%) and 3 (60%) cases, failed in one (8%) and one (20%) case and remained uncertain in one (8%) and one (20%) case, respectively (Table 1).

The information about possible risk factors in the herds separately for the S-, F- and U -herds is presented in Table 2: distance in meters between infected young pigs and disease-free pigs during the attempt, time between diagnosis of the disease and the beginning of the programme, age of the youngest pig remaining in the herd, time when infected and disease-free piglets were on same compound and treatment during the attempt.

All farmers except one had cleaned, disinfected and dried the facilities well. One farmer (S10) cleaned and disinfected all the rooms except the compartment for dry sows, where he used composting sawdust bedding. He changed only half of the bedding and did not clean the room for dry sows at all. On 8 farms (6 S-herds, 1 F-herd and 1 U-herd) the rooms for dry sows were cleaned, while the sows were in the room, otherwise the rooms were cleaned while they did not house any animals.

Eighteen farmers had initiated the programme on their farms between April and August. Fourteen of them (78%) had success, 2 (11.1%) had failed and 2 (11.1%) were unsure about the result. The remaining 3 herds started the programme between September and March and all of them succeeded.

Describing possible causes of failure

The failure was confirmed in herd F1 17 months and in herd F2 5 months after the beginning of the program. The reasons for failure could not be determined for the F-herds. Farm F1 started the eradication programme 5 months after the disease had been diagnosed with colostrum samples and used variant 2, i.e. housing infected and disease-free piglets 50 meters apart for 15 weeks. Herd F2 used variant 3 and started the programme 12 months after the disease had been diagnosed. The failure was possibly caused by the large number of animals which were about 10 months old. Two herds (U1 and U2) were reinfected by replacement gilts bought from infected herds without a quarantine period shortly after performing the eradication programme.

Estimation of the cost of the programme

Twelve farmers (57%) estimated the cost of the programme and the expenses associated with it

Table 2. Information about the eradication attempts from successful (S-herds), failed (F-herds) or uncertain (U-herds) herds in eliminating enzootic pneumonia.

Information	S-herds n = 17	F-herds N = 2	U-herds n = 2	Total n = 21
Distance (meters) between infected young pigs and disease-free pigs during the attempt				
Variant 1*	15, 10-20	–	–	10, 10-20
Variant 2*	100, 10-200	50	200	100, 10-200
Variant 3*	500, 500-5000	16000	200	500, 200-16000
Months from diagnosing the disease and the beginning of the programme*	12, 4-36	8.5, 5-12	7.5, 3-12	12, 3-36
Age of the youngest pig remaining in the herd (months)*	12, 8-18	11, 10-12	12, 10-14	12, 8-18
Time when infected and disease-free piglets were on same compound (weeks)*	9, 0-24	7.5, 0-15	6, 0-12	9, 0-24
Treatment during the programme, number of herds				
Lincomycin in feed	3	0	0	3
Lincomycin in feed + injection	7	1	0	8
Tiamulin in feed	6	1	1	8
Tiamulin in feed + lincomycin injection	1	0	0	1
No information about treatment	0	0	1	1

* = median, minimum–maximum,.
n (%) = number and percentage of the herds.
Variant 1 = infected young pigs were kept isolated in the same building as disease-free pigs.
Variant 2 = infected young pigs were kept on the same compound but not in the same building as disease-free pigs.
Variant 3 = only adult animals were kept on the same compound as disease-free pigs.

were a median of 1033 FIM (1 USD = 5.5 FIM) per sow on the farm (115-3750 FIM). For variants 1, 2 and 3 the expenses were 879 FIM (800-1293 FIM, 3 herds), 1110 FIM (115-3750 Fmk, 6 herds) and 1274 FIM (129-1800 FIM, 3 herds) per sow, respectively ($p>0.1$).

Discussion

An eradication programme against *M. hyopneumoniae* was carried out successfully in 81% of the herds. There seemed to be no difference in the success rate when the different variants are compared.

However, the number of failed herds (only 2 herds with true failure and another 2 with reinfection) is small. The present study provides data about how the eradication programmes can be performed with a minimum production interruption in small herds. Studies, where similar methods have been used are very few. *Zimmermann et al.* (1989) developed The Swiss method, where all animals older than 10 months were removed from the herd for the eradication. They succeeded in all of their eradication attempts, but after the programme some reinfections occurred. In Switzerland, as many as 110 herds had eradicated SEP by 1989 (*Zimmer-*

mann 1990). Interestingly, in the present study 2 out of 5 eradication programmes which used the Swiss method failed or remained uncertain. Other groups have achieved a good success rate with the Swiss method (*Lium et al.* 1994, *Baekbo et al.* 1994). *Wallgren et al.* (1993) housed also infected animals on 4 farms during the programme, where one herd failed to eradicate the disease.

Important factors in using variants 1 and 2 are the separation of the animal groups with different disease statuses, the length of time when infected young pigs are kept close to disease-free pigs as well as the number of infected animals and the number of animals at risk to be infected. We recommend that the groups should always be kept as far from each other as possible to avoid airborne transmission of *M. hyopneumoniae.* The distance between infected and uninfected animals is an important risk factor regarding the spread of infection of SEP (*Goodwin* 1985, *Jorsal & Thomsen* 1988). However, facilities on the farm can be used to cut down the expenses as shown in the present study. The length of time when infected young pigs are close to disease-free animals should be as short as possible. Also *Wallgren et al.* (1993) preferred the fast variant (about one month) over the slow variant (more than 3.5 months) of the programme. In the present study other factors seemed to be more important than the distance and the time period when infected young pigs were kept close to healthy piglets. It has to be noticed that these results cannot be generalised because of the small number of the herds. Anyway, when animals with different disease statuses are housed for a long time on the same compound, the airborne transmission of *M. hyopneumoniae* becomes more likely. Also other preventive measures may be forgotten in routine work (changing clothing, using separate equipment etc.). The distance involved cannot explain all the differences, other environmental factors need to be considered as well in determining the spread of the disease (*Stark et al.* 1992). Another important factor, the number of infected animals and the number of animals at risk to be infected, could not be followed in this study. No information about the matter was collected during the programme and it was not possible to remember the number of the animals in the different groups reliably afterwards. However, most of the herds were small and the number of the infected animals were most likely to be small, which may contribute to the good success rate of the programme.

The good co-operation between the farmer, the local veterinarian and the animal health service was an essential part in the programme. It is important that an individually tailored, detailed design for each farm is planned and followed throughout the programme by a veterinarian. Possible risk factors need to be clarified for the farmer whatever variant of the programme is selected: the length of time between the diagnosis of the disease and the initiation of the eradication programme, the youngest animal left in the herd, cleaning of the facilities, and the spread of *M. hyopneumoniae* with air, equipment or personnel. The eradication programme should not be initiated until the infection has spread through the herd so that the old animals acquire immunity. In the present study the most likely reason for failure in farm F1 was the fact that they started the programme only 5 months after diagnosing the disease. However, the disease may have been present on the farm long before the positive samples, because no samples had been taken earlier. We recommend that after a reinfection there should be a time period of about 1 year until an eradication programme is attempted. In other studies the length of time between the diagnosis and the initiation of the eradication programme has not been reported at all or the information has been given only for some farms (*Zimmermann et al.* 1989, *Zimmer-*

mann 1990, *Lium et al.* 1994, *Baekbo et al.* 1994, *Wallgren et al.* 1993).

The Swiss method allows pigs older than 10 months to be left in the herd. However, *Zimmermann et al.* (1989) recommend that it is more advisable to keep only primiparous sows or older in the herd. Actually, not enough is known about the development of immunity in individual animals. According to *Zimmermann & Weiskopf* (1996) older sows provide piglets with higher levels of maternal antibodies and the possibility of a SEP carrier state in older sows is usually much lower. The younger the animals are the more likely they are to spread the infection. However, in our study one eradication attempt had succeeded even though animals younger than 10 months had been left in the herd permanently during the eradication. We did not collect the information about the number of young animals left in the herd, which would have been interesting. Actually, the herd which failed after using variant 3 (farm F2) had left a great number of gilts barely 10 months old, this was considered to be the most likely reason for the failure.

The survival of *M. hyopneumoniae* in different media has been studied widely. The organism can survive in a liquid medium at laboratory at room temperature for about 30 days and in a refrigerator for about 100 days, whereas in small pieces of pneumonic tissue the survival time is 7 days at room temperature (*Goodwin* 1972). *Friis* (1973) found that the organism did not survive air-drying at room temperature beyond approximately one week. Furthermore, the mycoplasmas are known to be susceptible to most disinfectants. *M. hyopneumoniae* is not very likely to be spread throughout premises or fomites (*Whittlestone* 1973). In this study it seemed not to be necessary to empty the rooms for dry sows for proper cleaning. However, good cleaning during the eradication programme reduces the infective pressure from other organisms as well, and is therefore recommended (*Wallgren et al.* 1993).

Seasonal patterns of outbreaks of the disease have been observed, the highest risk for reinfections being during the cold months of the year (*Stark et al.* 1992, *Jorsal & Thomsen* 1988). In the present study the effect of the season on the success rate of the eradication programmes could not be demonstrated, partly because the number of the programmes initiated during the cold months were so small. All three herds that started the programme during fall or winter succeeded.

Another important factor in the spread of infections is purchasing of replacement animals. As shown in the present study, a proper quarantine scheme is extremely important. The results of 2 herds was uncertain, because they had purchased new animals from infected herds with no quarantine measures and this way ruined their work in eradicating SEP. The disease status of the herd selling the animals should be clarified carefully and proper quarantine measures should be used always for incoming animals. Also in a Swiss study the number of reinfections has been significant: 8 herds out of 110 (7.3%) had been reinfected after the eradication programme. However, the reasons for reinfections were not discussed (*Zimmermann* 1990).

M. hyopneumoniae has been found to be susceptible to a wide variety of antimicrobials in vitro (*ter Laak et al.* 1991). Several different antibiotics have been used in eradication programmes: tiamulin, chlortetracyclin + tylosin + sulfadimidin, lincomycin, enrofloxacin and chlortetracyclin + tiamulin (*Zimmermann et al.* 1989, *Wallgren et al.* 1993, *Lium et al.* 1994, *Madsen & Larsen* 1996, *Baekbo et al.* 1994). The variety is wide and further research is needed to clarify if medication is really an essential part of the eradication process. In the present study the choice of medication did not

seem to affect the success rate of the programme. However, the number of herds was small and no statistical methods could be used to test the results. *Zimmermann et al.* (1989) were of the opinion that the nucleus of the eradication programme was the piglet-free period and the medication is given only to be on the safe side. In one study a successful eradication programme was carried out even with no medications used for 28 gilts (*Sorensen & Barfod* 1992). An interesting point is also the fact that the doses of medications in the present study were noticeably lower than those recommended in some other studies (*Zimmermann et al.* 1989, *Zimmermann & Weiskopf* 1996), which gives further evidence for the theory that the medication is possibly not an essential part of the eradication programme. However, in the present study one could also conclude that 2 eradication programmes failed possibly because of insufficient doses of medication.

The ELISA method has been used for testing blood (*Sorensen et al.* 1992. *Sorensen et al.* 1993, *Morris et al.* 1995) or colostrum (*Levonen* 1994, *Rautiainen et al.* 1996, *Sorensen et al.* 1993) samples for *M. hyopneumoniae.* In order to prevent false positive diagnosis before the eradication programme only herds, where at least 10% of the sows had antibodies for *M. hyopneumoniae,* were regarded as truly infected herds. The strict clinical follow-up both in the farrowing units and especially in the finishing units buying the health-class piglets and the regular serological survey in the farrowing herds prove the success of the programmes in the S-herds. The percentage of lung condemnations after the eradication programme is not unambiguous in all the herds studied. Hence, lung condemnations should always be verified by bacteriology and histopathology when using them in disease control. It is notable that also the percentage of condemned lungs had decreased in F+U-herds, which is most likely due to the lowered infection pressure after the eradication programme.

There was a tendency for variant 1 being less expensive per sow than variant 2 and variant 2 being less expensive than variant 3. However, there were no statistical differences. The farmers found it very difficult to estimate the total costs of the programme. Only slightly over half of the farmers gave some estimates, which may bias the results considerably. Especially losses due to production interruption was difficult to evaluate properly, and in most cases this was the most expensive part in the programme.

The eradication attempt was successful in many small herds even though some infected animals were reared close to disease-free animals for a short period of time. The good co-operation between the farmer, the local veterinarian and the animal health service of the slaughterhouse was an essential part of the initiation and the follow-up of the programme. The present study describes the possible causes of failure which need to be considered in each individual plan at the herd level and the possible expenses associated with an eradication attempt.

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References

Baekbo P, Madsen KS, Aagaard M and Szancer J: Eradication of *Mycoplasma hyopneumoniae* from infected herds without restocking. Proc. Int. Pig Vet. Soc., Bangkok, Thailand, 1994, 135.

Friis NF: Resistance of porcine mycoplasmas to drying. Acta vet. scand. 1973, *14,* 489-491.

Goodwin RF: The survival of *Mycoplasma suipneumoniae* in liquid medium, on solid medium and

in pneumonic tissue. Res. Vet. Sci. 1972, *13,* 203-204.

Goodwin RF: Apparent reinfection of enzootic-pneumonia-free pig herds: search for possible causes. Vet. Rec. 1985, *116,* 690-694.

Jorsal SE, Thomsen BL: A Cox regression analysis of risk factors related to Mycoplasma suipneumoniae reinfection in Danish SPF-herds. Acta vet. scand. 1988, Suppl. *84,* 436-438.

ter Laak EA, Pijpers A, Noordergraaf JH, Schoevers EC, Verheijden JHM: Comparison of methods for in vitro testing of susceptibility of porcine *Mycoplasma* species to antimicrobial agents. Antimicrobial Agents and Chemotherapy 1991, *35,* 228-233.

Levonen K: Detection of enzootic pneumonia in pig herds using an enzyme- linked immunosorbent assay in sow colostrum. Res.Vet. Sci. 1994, *56,* 111-113.

Lium B, Skomsoy A, Jorgensen A, Austbo O, Loe B, Szancer J: Attempt to eradicate Mycoplasma hyopneumoniae from selected farrowing to finishing herds. Proc. XVII Nordic Vet. Congress, Reykjavik, Iceland, 1994, *1,* 141.

Madsen KS, Larsen K: Attempt to eradicate *Mycoplasma hyopneumoniae* and *Actinobacillus pleuropneumoniae* from a sow herd, using a strategy with feed medication with Baytril ier (enrofloxacin) powder 2,5%. Proc. Int Pig Vet. Soc., Bologna, Italy, 1996, 227.

Morris CR, Gardner IA, Hietala SK, Carpenter TE, Anderson RJ, Parker KM: Seroepidemiologic study of natural transmission of *Mycoplasma hyopneumoniae* in a swine herd. Prev. Vet. Med. 1995, *21,* 323-337.

Rautiainen E, Nyberg M, Levonen K: The use of sow colostrum samples for regular herd health control of mycoplasma hyopneumoniae infection. Proc Int. Pig Vet. Soc, Bologna, Italy, 1996, 219.

Sorensen V, Barfod K, Feld NC: Evaluation of a monoclonal blocking ELISA and IHA for antibodies to *Mycoplasma hyopneumoniae* in SPF-pig herds. Vet. Rec. 1992, *130,* 488-490.

Sorensen V, Barfod K: Establishing of *Mycoplasma hyopneumoniae* serological negative herd. Proc Int. Pig Vet. Soc., Hague, Netherlands, 1992, 316.

Sorensen V, Barfod K, Feld NC, Vraa-Andersen L: Application of enzyme-linked immunosorbent assay for the surveillance of *Mycoplasma hyopneumoniae* infection in pigs. Rev. sci. tech. Off. int. Epiz. 1993, *12,* 593-604.

Stark KDC, Keller H, Eggenberger E: Risk factors for the reinfection of specific pathogen-free pig breeding herds with enzootic pneumonia. Vet. Rec. 1992, *131,* 532-535.

Tuovinen VK, Heinonen M, Suutari E: LSO 2000 quality chain produces non-medicated pork. Proc Int. Soc. An. Hyg., Helsinki, Finland 1997, *1,* 180-183.

Waldmann O, Radtke G: Erster Bericht über Erfolge der Bekämpfung der Ferkelgrippe durch die Riemser Einzelhüttenanlage (in German). Berl. Tierärztl. Woschr. 1937, *53,* 241-248.

Wallgren P, Sahlander P, Hasslebäck G, Heldmer E: Control of infections with *Mycoplasma hyopneumoniae* in swine herds by disrupting the chain of infection, disinfection of buildings and strategic medical treatment. J. Vet. Med. B. 1993, *40,* 157-169.

Whittlestone P: Enzootic pneumonia of pigs (EPP). In: C. A. Brandly and C. E. Cornelius (Editors), Advances in Veterinary Science and Comparative Medicine. Academic Press, New York 1973, *17,* 1-55.

Zimmermann W, Odermatt W, Tschudi P: Enzootische Pneumonie (EP): die Teilsanierung EP-reinfizierter Schweinezuchtbetriebe als Alternative zur Totalsanierung (In German with English abstract). Enzootic pneumonia (EP): partial sanitation in EP-reinfected pig herds as an alternative method to total sanitation. Schweiz. Arch. Tierheilk. 1989, *131,* 179-186.

Zimmermann W: Erfahrungen mit der EP-Teilsanierung im Tilgungsprogramm des Schweizerischen Schweinegesundheitsdienstes (SGD) (In German with English abstract). Experience in the EP sanitation programme to eradicate EP. Tierärztl. Umschau 1990, *45,* 556, 559-562.

Zimmermann W, Weiskopf S: The use of lincomycin in an enzootic pneumonia eradication program in pig herds. Proc. Int. Pig Vet. Soc., Bologna, Italy, 1996, 235.

Sammanfattning

Sanering av Mycoplasma hyopneumoniae –infekterade svinbesättningar som vill ansluta sig till hälsoklassen LSO 2000.

Saneringsresultat av smittosam grishosta (enzootisk pneumoni) studerades i suggbesättningar som ingick i hälsoklassen LSO 2000. Besättningarna i hälso-

klassen behöver vara fria från grishosta, svindysenteri, skabb och nyssjuka. Tjugoen besättningar med grishosta (*Mycoplasma hyopneumoniae*) sanerades med olika varianter av programmet som baserade sig på separering av fullvuxna djur från unga djur under 2 veckors tid. De unga djuren återförenades inte med de fullvuxna djuren. Variant 1, där infekterade grisar hölls i samma byggnad som de fullvuxna djuren, användes i 4 besättningar. Variant 2, där infekterade grisar hölls i skild byggnad, men på samma gård som de fullvuxna djuren, användes på 12 gårdar. Variant 3, där bara de vuxna djuren hölls kvar på gården, användes i 5 besättningar. Saneringen lyckades i 81% och mislyckades eller gav motstridiga resultat i 19% av besättningarna. Resultatet följdes upp med hjälp av 1) ofta återkommande kliniska uppföljningsundersökningar av hälsotillståndet i besättningen och i slaktsvinbesättningarna av LSO 2000 hälsoklass dit grisarna transporterats 2) serologiska undersökningar av mjölk och serum prov. Denna studie beskriver möjliga riskfaktorer som leder till att saneringsprogrammet mislyckas: ett kort avstånd mellan de infekterade och oinfekterade djuren, tidperioden mellan upptäckten av infektionen och början av saneringsprogrammet, åldern av det yngsta djuret som hållits på besättningen i samband med saneringen, tidsperiodens längd då svin med olika hälsostatus behölls på gården, användadet av läkemedel, rengörning av svinstallet och inverkan av årstiden. Ett gott samarbete mellan djurägarna, den praktiserande veterinären och slakteriorganisationens djurhälsovård var av avgörande betydelse för iniatieringen och uppföljningen av programmet. Det andra målet av denna undersökning var att samla information över kostnaderna för besättningarna som programmet medförde. Endast 57% av besättningarna gav information över kostnader som programmet medförde. För varianterna 1, 2 och 3 var de beräknade kostnaderna respektive 879, 1110 och 1274 finska mark ($p>0.1$) per sugga (1 USD = 5.5 FIM).

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